AD-A101 772 FOREST PRODUCTS LAB MADISON WI F/G 11/12
MARINE EXPOSURE OF PRESERVATIVE-TREATED SMALL WOOD PANELS.(U)
APR 81 B R JOHNSON, D I GUTZMER
UNCLASSIFIED FSRP-FPL-399 NL

1 OF 1
AD
A101 772

END
DATE
FILMED
8-81
DTIC

LEVEL II

12

United States
Department of
Agriculture

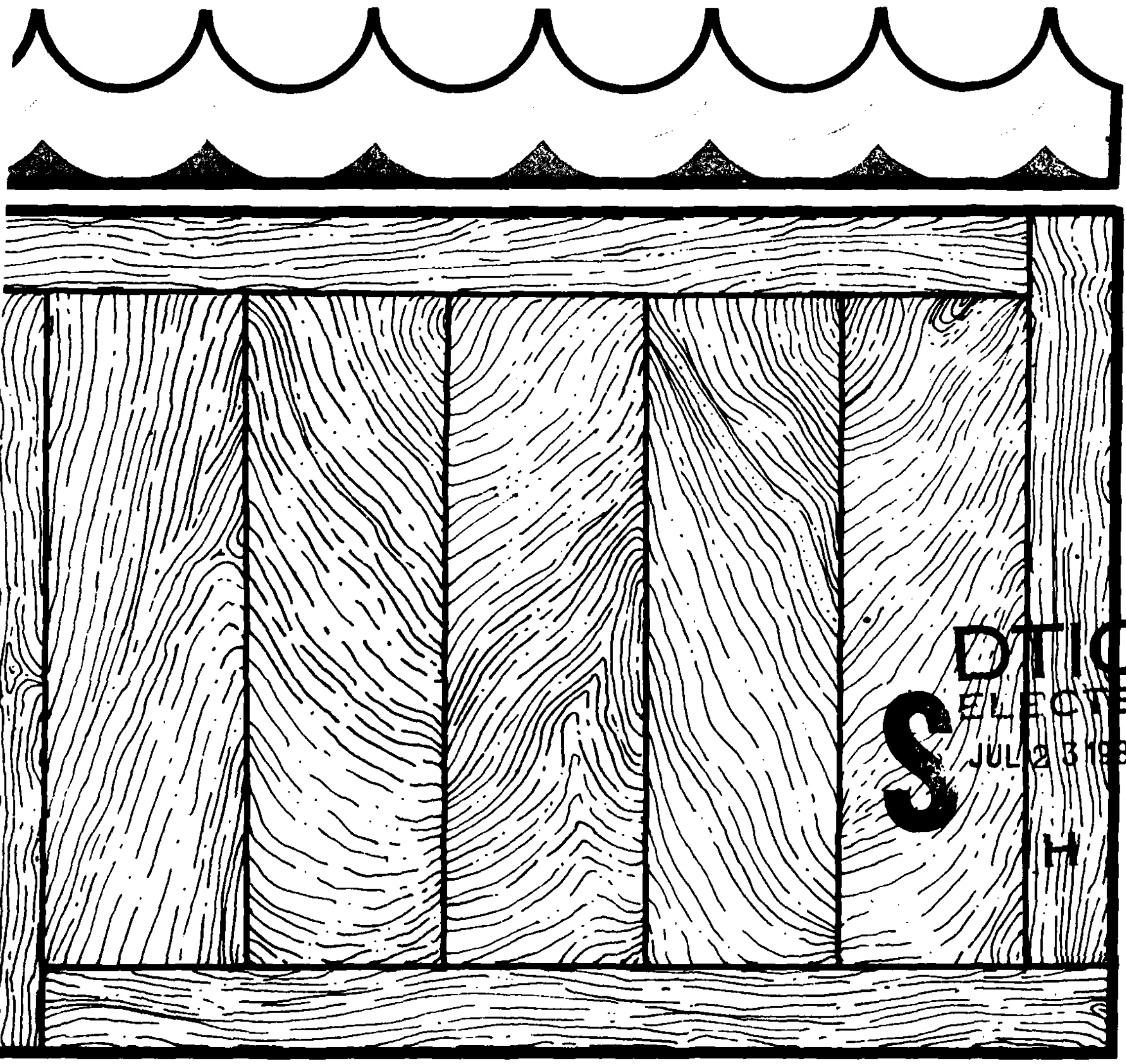
Forest Service

Forest
Products
Laboratory

Research
Paper
FPL 399

April 1981

Marine Exposure of Preservative-Treated Small Wood Panels



Abstract

[illegible] panels treated with a variety of preservatives and candidate preservatives are tabulated. Materials tested include creosotes, modified creosotes, [illegible] dual treatments, and chemically modified wood. Many treated panels remain free of marine borer attack after 9 years' exposure.

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory[1]

Research
Paper
FPL 399

Marine Exposure of Preservative-Treated Small Wood Panels.

~~Compiled by~~
10 BRUCE B. JOHNSON, Research Technologist
~~and~~
DAVID I. GUTZMER, Technician

14 FSRP-FPL-399

11 Apr 81

12 17

Introduction

The effectiveness of conventional wood preservatives—such as creosote, copper-arsenic-containing waterborne systems, and pentachlorophenol—in preventing biodegradation of wood above ground, in soil contact, and in fresh-water exposures is well documented and generally well accepted. However, in the marine environment, conventional preservatives are less effective, particularly in warmer waters where the crustacean-borer *Limnoria tripunctata* is prevalent.

This organism is tolerant of creosote, which in other respects is a very satisfactory marine preservative. Because of observations that metallic salts deter *Limnoria* attack and that creosote impedes teredine attack, a study was initiated in 1969 to determine what combination of preservative type, quality, and quantity is the most effective and economical single and/or dual treatment for the protection of wood in a marine environment where *L. tripunctata* is abundant.

Two reports[2] on this study have been published. This report is now being published because a number of other preservative treatments have been added to the test since the original 1969 installation and because the closure of the Key West Naval Base has necessitated a recent move from our exposure site. This report presents the last data from that site. Data from the new site, another Key West harbor, will be reported in the near future. It is hoped that this compilation of exposure data will be useful to others in the search for a better marine preservative.

Procedures

With few exceptions, ASTM Standard D-2481, Standard Method of Accelerated Evaluation of Wood Preservatives for Marine Service by Means of Small-Size Specimens, has been followed. Specimens of southern pine sapwood, 0.24 to 0.39 growth rings per mm (6-8/in.), were machined into vertical-grain panels 6 x 38 x 152 mm (1/4 x 1-1/2 x 6 in.). The conditioned panels were weighed to allow gain-in-weight determinations of preservative retention. In most cases, treatments were carried out at the Forest Products Laboratory. In some cases, panels were sacrificed to determine retentions by chemical analysis. Except where noted otherwise, five replicate panels per treatment variable were placed in test.

Racks to which the panels were attached for marine exposure were constructed of fiberglass-reinforced polyester angle and assembled with stainless steel eye bolts and Monel machine screws. These materials have performed satisfactorily. However, a material resistant to corrosion and abrasion and otherwise suitable for the panel identification tags has been a problem. Polypropylene (75 mil) has held up well, but undoubtedly other synthetics would also suffice. Some tags such

[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[2] Johnson, B. R., L. R. Gjovik, and H. G. Roth, 1973. Single- and dual-treated panels in a semi-tropical harbor: Preservative and retention variables and performance. Am. Wood-Preservers' Assoc. Proc. 69:207-215.

Johnson, B. R., 1977. Performance of single- and dual-treated panels in a semitropical harbor, Progress Report No. 2. Am. Wood-Preservers' Assoc. Proc. 73:174-177.

14170

as Monel should be avoided because they may leach copper into the upper portion of the test panel.

From December 1969, when the first racks with attached panels were installed, through January 1979, the specimens were suspended 1 to 2 feet below the low-tide level with nylon rope under Pier No. 1 in the harbor of the Key West Naval Station, Key West, Florida. The racks were about even with the base of the "hour glassed" portion of heavily attacked fender piles along the pier.

Although the ASTM Standard calls for monthly inspection of test panels of this size, inspections made at semiannual intervals seemed adequate. In 1973 and 1974, inspections were made only once a year. The return to semiannual inspections was made because of the appearance of a calcarious fouling which partially coated the specimens and was considered to be a probable hindrance to borer attack.

At each inspection, all panels were scraped free of fouling and rated for the type and extent of marine-borer attack. Panels were visually rated on a scale from 10 indicating no more than trace attack through 9 for light attack, 7 for moderate, 4 for heavy attack, and 0 for destruction or complete loss of panel integrity. Untreated control panels were replaced at each inspection as a check on borer activity. These controls confirmed the prevalence of teredine borers and several species of *Limnoria*, including *L. tripunctata*.

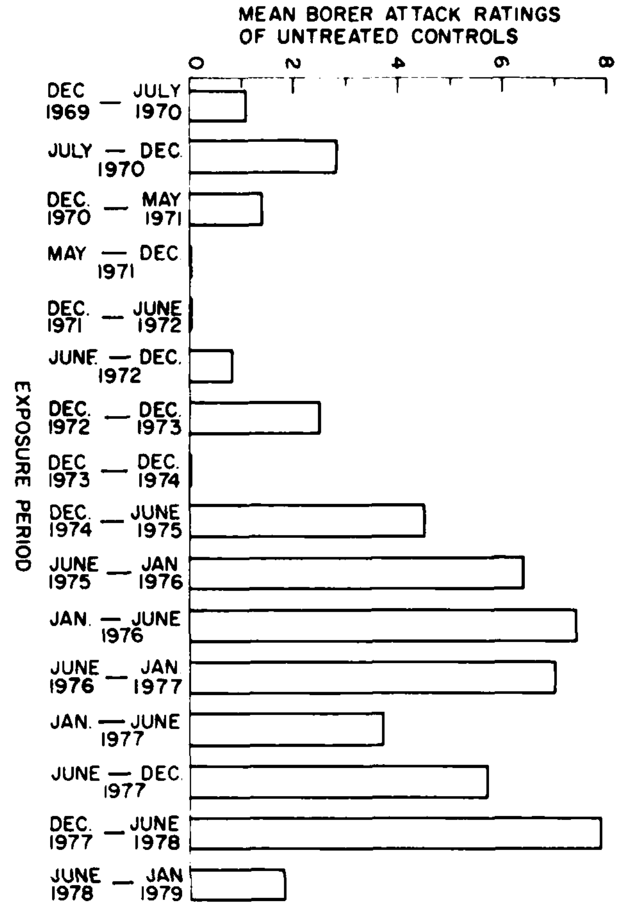


Figure 1.—Average condition of untreated control panels after various periods of exposure to marine borer attack.

Results

Preservatives and preservative processes tested and reported here are indexed in Table 1. Further information on preservative composition and treating data is generally available from the Forest Products Laboratory (FPL) contact listed with the performance data in Tables 2-1 through 5. These tables also list outside cooperators where applicable. Relevant federal specifications and American Wood-Preservers' Association (AWPA) standards are given where available. Retentions are by gain in weight. For salts, retentions are expressed on an oxide basis. Retentions and indices of condition (mean ratings) are, in most cases, averages of five specimens.

The column showing "months exposure to index below 6" will be the most useful for comparisons of preservative effectiveness. An index of 6 denotes moderate to heavy borer attack. Experience has shown that, once attack progresses beyond that of trace or trials, it proceeds at a fairly steady rate. Retention will, of course, need to be considered in any such comparisons. Also, control panels have exhibited changes in extent of borer attack over the years (Fig. 1). Hence, where two preservatives were exposed at different times, the performance of untreated (control) panels during these times should be considered. Finally, this test measures relative effectiveness of preservatives in small sawn specimens at one exposure site. Extrapolation of results to piling is invalid on several counts: these panels provide an accelerated test because they expose more of the preferred earlywood to *Limnoria* attack than do round specimens (or piling); the greater surface-to-volume ratio of small panels allows for more rapid loss of preservative; the cross section of small panels is small enough that *Limnoria* can penetrate deeply and still obtain good exchange of oxygenated water, whereas in piling, wave action and abrasion from floating debris must break away surface areas to allow the *Limnoria* to burrow more deeply.

Conclusions

A few general conclusions are offered: At Key West, moderate to high retentions of CCA and ACA provide more protection than high retentions of creosote. Dual treatments protect longer than do light to moderate retentions of CCA or ACA. After 9 years of exposure, 1 pound per cubic foot (lb/ft^3) CCA is performing as well as 2.5 lb/ft^3 CCA—i.e., no attack. In the dual treatment with a standard grade creosote, 1 lb/ft^3 CCA or ACA has performed as well as 2.5 lb/ft^3.

Table 1.—Index to treatments tested

Treatment	Table No.
Creosotes	
English vertical retort	2-1
Coal-tar, land and fresh-water grade	2-2
Coal-tar, marine grade	2-3
Coal-tar, with supplements	2-4
Coal-tar, with additional naphthalene	2-5
Waterborne salts	
Chromated copper arsenate (B)	3-1
Chromated copper arsenate (C)	3-2
Ammoniacal copper arsenate	3-3
Acid copper chromate	3-4
Ammoniacal copper borate	3-5
Double diffusion	3-6
Ammoniacal copper fluoride	3-7
Chromated copper fluoride	3-8
Copper tetra- and pentachlorophenate	3-9
Dual treatments	
Chromated copper arsenate (B) and English vertical-retort creosote	4-1
Chromated copper arsenate (B) and land-grade coal-tar creosote	4-2
Chromated copper arsenate (B) and marine-grade coal-tar creosote	4-3
Chromated copper arsenate (C) and English vertical-retort creosote	4-4
Chromated copper arsenate (C) and land-grade coal-tar creosote	4-5
Chromated copper arsenate (C) and marine-grade coal-tar creosote	4-6
Ammoniacal copper arsenate and English vertical-retort creosote	4-7
Ammoniacal copper arsenate and land-grade coal-tar creosote	4-8
Ammoniacal copper arsenate and marine-grade coal-tar creosote	4-9
Ammoniacal copper borate and marine-grade coal-tar creosote	4-10
Acid copper chromate and marine-grade coal-tar creosote	4-11
Chromated copper fluoride and marine-grade coal-tar creosote	4-12
Chemical modification	5

Table 2-1.—English vertical-retort creosote[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft^3				
9.7	12/69	R_L[2]	18	12
14	12/69	R_L	18	12
27	12/69	R_L	30	24

[1] Study supported in part by the U.S. Navy Naval Facilities Engineering Command (NFEC). FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 2-2.—Coal-tar creosote, land and fresh-water grade (AWPA P-1, Federal Specification TT-C-645)[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft^3				
6.6	12/69	R_L[2]	24	12
16	12/69	R_L	36	24
24	12/69	R_L	109	36

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 2-3.—Coal-tar creosote, marine grade (AWPA P-13, Federal Specification TT-C-645)[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
6.5	12/69	R_L[2]	24	12
15	12/69	R_L	48	24
28	12/69	R_L	66	48
39	12/70	7	97	—
15	1/76	6	37	—
[3]20	1/77	7	24	—

[1] Study supported in part by NFEC Organic Materials Division (OMD), Koppers Co. (contact D. A. Webb), and J. H. Baxter and Co. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).
[3] Based on 10 replicates.

Table 2-4.—Coal-tar creosote (AWPA P-13, Federal Specification TT-C-645) with supplements[1]

Preservative supplement	Retention[2]	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Lb/ft³				
10 pct PAC[3]	20	6/76	5	31	31
10 pct PAC and 20 pct naphthalene	18	6/76	4	31	31
20 pct PAC and 20 pct naphthalene	19	6/76	7	31	—

[1] Study supported in part by NFEC OMD and Koppers Co. (contact D. A. Webb). FPL contact L. R. Gjovik and B. R. Johnson.
[2] 10 replicates per treatment.
[3] PAC = A fraction of creosote containing a high percentage of crystals, primarily of phenanthrene, anthracene, and carbozole.

Table 2-5.—Coal-tar creosote (AWPA P-13, Federal Specification TT-C-645) with supplemental naphthalene[1]

Preservative supplement	Retention[2]	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Lb/ft³				
10 pct naphthalene	[3]19	6/75	3	43	43
	36	12/77	10	13	—
20 pct naphthalene	[3]17	6/75	2	43	30
	22	6/76	4	31	31
	34	12/77	10	13	—
30 pct naphthalene	[3]19	6/75	6	43	—
	22	6/76	3	31	31
	31	12/77	10	13	—
40 pct naphthalene	38	12/70	10	97	—
	[3]18	6/75	1	43	36
	18	6/76	2	31	31
	38	12/77	10	13	—

[1] Study supported in part by NFEC OMD and Koppers Co. (contact D. A. Webb). FPL contact B. R. Johnson.
[2] 10 replicates per treatment except 12/70 installation with 5 replicates.
[3] Full-cell treatments with toluene dilution of the creosote.

Table 3-1.—Chromated copper arsenate (AWPA P-5 Type B, Federal Specification TT-W-550 Type II)[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
0.23	12/69	$R_{L,T}$[2]	30	24
.57	12/69	$R_{L,T}$	78	60
1.1	12/69	10	109	—
2.4	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L), teredines (T).

Table 3-2.—Chromated copper arsenate (AWPA P-5 Type C, Federal Specification TT-W-550 Type III)[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
0.25	12/69	$R_{L,T}$[2]	36	30
.60	12/69	$R_{L,T}$	102	72
1.1	12/69	10	109	—
2.4	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L), teredines (T).

Table 3-3.—Ammoniacal copper arsenate (AWPA P-5, Federal Specification TT-W-549)[1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
0.23	12/69	$R_{L,T}$[2]	36	30
.56	12/69	$R_{L,T,E}$	78	72
1.1	12/69	4	109	109
2.3	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L), teredines (T), microbial erosion (E).

Table 3-4.—Acid copper chromate (AWPA P-5, Federal Specification TT-W-546)[1]

Retention[2]	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
0.25	6/75	7	43	—
.25	1/76	7	36	—
.60	1/76	10	36	—
1.2	1/76	10	36	—
2.8	1/76	10	36	—

[1] Study supported in part by Koppers Co. Forest Products Division (FPD) (contact W. T. Henry). FPL contact L. R. Gjovik.
[2] 15 replicates per treatment except 6/75 installation with 8 replicates.

Table 3-5.—Ammoniacal copper borate[1]

Retention[2]	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft^3				
1.3	6/75	7	43	—
.25	1/76	3	36	36
.60	1/76	10	36	—
1.2	1/76	10	36	—
2.5	1/76	10	36	—

[1] Study supported in part by J. H. Baxter and Co. FPL contact B. R. Johnson.
[2] As $2CuO \bullet B_2O_3$. 15 replicates per treatments.

Table 3-6.—Double diffusion[1,2]

Preservative formulation	Duration of soak	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Hr				
1.5 pct NaF and 1.5 pct $CuSO_4$	96 138	6/75	10	43	—
1.5 pct NaF and 1.5 pct ACC	96 138	6/75	8	43	—

[1] FPL contact L. R. Gjovik.
[2] Samples saturated with water, soaked in NaF, then soaked in $CuSO_4$ or acid copper chromate (ACC). 8 replicates per treatment.

Table 3-7.—Ammoniacal copper fluoride[1]

Preservative formulation	Retention[2]	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Lb/ft^3				
CuO/F = 5.6	0.52	1/76	10	36	—
	.90	1/76	10	36	—
CuO/F = 2.4	.62	1/76	10	36	—
	1.3	1/76	10	36	—
	2.4	1/76	10	36	—
CuO/F = 1.2	.61	1/76	10	36	—
	1.2	1/76	10	36	—
	2.6	1/76	10	36	—

[1] Study supported in part by J. H. Baxter and Co. (contact G. E. Martin). FPL contact L. R. Gjovik.
[2] 10 replicates per treatment.

Table 3-8.—Chromated copper fluoride [1]

Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³				
0.23	6/77	7	19	—
.60	6/77	10	19	—
1.2	6/77	10	19	—
2.5	6/77	10	19	—

[1] Study supported in part by Simonsen Chemical Co. (contact W. J. Simonsen). FPL contact L. R. Gjovik.

Table 3-9.—Copper salts of tetrachlorophenol and pentachlorophenol [1]

Preservative formulation	Retention	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Lb/ft³				
FP No. 6—0.855 pct tetrachlorophenol and 0.145 pct CuO	.36	6/78	10	7	—
FP No. 5—3.42 pct tetrachlorophenol and 0.58 pct CuO	1.7	6/78	10	7	—
FP No. 8—0.855 pct tetrachlorophenol and 0.145 pct CuO	.28	6/78	10	7	—
FP No. 7—3.42 pct tetrachlorophenol and 0.145 pct CuO	1.4	6/78	10	7	—
FP No. 10—0.855 pct pentachlorophenol and 0.145 pct CuO	.39	6/78	10	7	—
FP No. 9—3.42 pct pentachlorophenol and 0.58 pct CuO	1.5	6/78	10	7	—

[1] Study supported in part by Reichhold Chemcials, Inc. (contact J. Amundsen). FPL contact B. R. Johnson.

Table 4-1.—Dual treatment with chromated copper arsenate (P-5, B) and English vertical-retort creosote[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
------ Lb/ft³	------				
0.25	9.0	12/69	$R_{L,T}$[2]	48	36
.25	16	12/69	$R_{L,T}$	72	60
.25	27	12/69	R_L	78	30
.59	7.9	12/69	9	109	—
.59	13	12/69	3	109	109
.59	30	12/69	2	109	102
1.1	8.1	12/69	10	109	—
1.1	11	12/69	9	109	—
1.1	25	12/69	10	109	—
2.4	9.0	12/69	10	109	—
2.4	16	12/69	10	109	—
2.4	24	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L), teredines (T).

Table 4-2.—Dual treatment with chromated copper arsenate (P-5, B) and coal-tar creosote (P-1)[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
------ Lb/ft³	------				
0.22	6.8	12/69	R_L[2]	102	72
.22	14	12/69	R_L	109	96
.22	25	12/69	2	109	102
.57	7.1	12/69	6	109	—
.57	18	12/69	9	109	—
.57	18	12/69	10	109	—
1.1	5	12/69	10	109	—
1.1	16	12/69	10	109	—
1.1	18	12/69	10	109	—
2.3	5	12/69	10	109	—
2.3	16	12/69	10	109	—
2.3	21	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-3.—Dual treatment with chromated copper arsenate (P-5, B) and coal-tar creosote (P-13)[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
——— Lb/ft³ ———					
0.23	6.7	12/69	R_L[2]	78	66
.23	13	12/69	1.4	109	102
.23	24	12/69	3.2	109	102
.59	5.2	12/69	10	109	—
.59	18	12/69	10	109	—
.59	23	12/69	10	109	—
1.1	4.2	12/69	10	109	—
1.1	18	12/69	10	109	—
1.1	19	12/69	10	109	—
2.3	4.8	12/69	10	109	—
2.3	19	12/69	10	109	—
2.3	21	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-4.—Dual treatment with chromated copper arsenate (P-5, C) and English vertical-retort creosote[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
——— Lb/ft³ ———					
0.25	7.2	12/69	R_L[2]	90	48
.25	16	12/69	4	109	109
.25	24	12/69	R_L	78	—
.60	7.6	12/69	7	109	—
.60	18	12/69	9	109	—
.60	23	12/69	6	109	—
1.1	9.2	12/69	10	109	—
1.1	13	12/69	10	109	—
1.1	27	12/69	9	109	—
2.6	9.4	12/69	10	109	—
2.6	13	12/69	10	109	—
2.6	18	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-5.—Dual treatment with chromated copper arsenate (P-5, C) and coal-tar creosote (P-1)[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
------ Lb/ft³	------				
0.22	5.7	12/69	R_L[2]	66	60
.22	13	12/69	R_L	109	102
.22	16	12/69	5	109	102
.59	4.8	12/69	9	109	—
.59	17	12/69	10	109	—
.59	22	12/69	10	109	—
1.1	7	12/69	10	109	—
1.1	15	12/69	10	109	—
1.1	23	12/69	10	109	—
2.6	7.6	12/69	10	109	—
2.6	12	12/69	10	109	—
2.6	21	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-6.—Dual treatment with chromated copper arsenate (P-5, C) and coal-tar creosote (P-13)[1]

Retention: Chromated copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
------ Lb/ft³	------				
0.24	5.2	12/69	R_L[2]	90	72
.24	11	12/69	R_L	109	102
.24	19	12/69	7	109	—
.60	4.3	12/69	10	109	—
.60	16	12/69	9	109	—
.60	18	12/69	10	109	—
1.1	5.7	12/69	10	109	—
1.1	12	12/69	10	109	—
1.1	22	12/69	10	109	—
2.5	6.1	12/69	10	109	—
2.5	12	12/69	10	109	—
2.5	24	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-7.—Dual treatment with ammoniacal copper arsenate (P-5) and English vertical-retort creosote[1]

Retention: Ammoniacal copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.24	8.3	12/69	R_L[2]	109	78
.24	12	12/69	R_L	90	78
.24	26	12/69	R_L	109	90
.56	8.9	12/69	8	109	—
.56	12	12/69	$R_{L,E}$	102	90
.56	25	12/69	4	109	102
1.1	8.4	12/69	8	109	—
1.1	12	12/69	10	109	—
1.1	23	12/69	10	109	—
2.2	8.2	12/69	10	109	—
2.2	11	12/69	10	109	—
2.2	27	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L), microbial erosion (E).

Table 4-8.—Dual treatment with ammoniacal copper arsenate (P-5) and coal-tar creosote (P-1)[1]

Retention: Ammoniacal copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.22	5.4	12/69	R_L[2]	84	66
.22	12	12/69	R_L	109	96
.22	21	12/69	3	109	102
.56	5.7	12/69	R_L	109	96
.56	14	12/69	6	109	—
.56	24	12/69	7	109	—
1.1	6.1	12/69	10	109	—
1.1	12	12/69	10	109	—
1.1	26	12/69	10	109	—
2.3	6.1	12/69	10	109	—
2.3	13	12/69	10	109	—
2.3	25	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-9.—Dual treatment with ammoniacal copper arsenate (P-5) and coal-tar creosote (P-13)[1]

Retention: Ammoniacal copper arsenate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.23	5.7	12/69	R_L[2]	96	72
.23	12	12/69	R_L	102	90
.23	24	12/69	6	109	—
.57	6	12/69	5	109	109
.57	12	12/69	6	109	—
.57	23	12/69	8	109	—
1.1	6.4	12/69	10	109	—
1.1	13	12/69	10	109	—
1.1	24	12/69	10	109	—
2.4	5.9	12/69	10	109	—
2.4	13	12/69	10	109	—
2.4	25	12/69	10	109	—

[1] Study supported in part by NFEC. FPL contact B. R. Johnson.
[2] R = Removed when destroyed by *Limnoria* (L).

Table 4-10.—Dual treatment with ammoniacal copper borate and coal-tar creosote (P-13)[1]

Retention[2]: Ammoniacal copper borate	Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.25	13	1/76	9	36	—
.60	12	1/76	10	36	—
1.2	15	1/76	10	36	—
2.5	13	1/76	10	36	—

[1] Study supported in part by J. H. Baxter and Co. FPL contact B. R. Johnson.
[2] 15 replicates per treatment.

Table 4-11.—Dual treatment with acid copper chromate (P-5) and coal-tar creosote (P-13)[1]

Retention: Acid copper chromate	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.25	16	1/76	10	36	—
.60	16	1/76	10	36	—
1.2	16	1/76	10	36	—
2.8	16	1/76	10	36	—

[1] Study supported in part by Koppers Co. FPD (contact W. T. Henry). FPL contact L. R. Gjovik.

Table 4-12.—Dual treatment with chromated copper fluoride and coal-tar creosote (P-13)[1]

Retention: Chromated copper fluoride	Retention: Creosote	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
Lb/ft³	Lb/ft³				
0.21	16	1/77	10	19	—
.57	19	1/77	10	19	—
1.1	21	1/77	10	19	—
2.3	19	1/77	10	19	—

[1] Study supported in part by Simonsen Chemical Co. (contact W. J. Simonsen). FPL contact L. R. Gjovik.

Table 5.—Chemical modification[1]

Reagent	Weight gain	Installation date	Present index of condition	Total months exposure	Months exposure to index below 6
	Pct				
Butylene oxide	[2]23.7	12/77	10	13	—
	[3]28.5	6/78	10	7	—
Propylene oxide	[4]22.1	6/75	10	43	—
	[5]26.6	6/75	10	43	—
	[6]31.6	6/75	10	43	—

[1] FPL contact R. M. Rowell.
[2] 10 replicates.
[3] 12 replicates.
[4] 3 replicates.
[5] 5 replicates.
[6] 2 replicates.

PR 6-2

U.S. Forest Products Laboratory

Marine Exposure of Preservative-Treated Small Wood Panels, by Bruce R. Johnson and David I. Gutzmer, Madison, Wis., FPL 1981.

14 pp. (USDA For. Serv. Res. Pap. FPL 399)

Results of marine exposure at Key West, Fla., of small wood panels treated with a variety of preservatives and candidate preservatives are tabulated. Materials tested include creosotes, modified creosotes, waterborne salts, dual treatments and chemically modified wood. Many treated panels remain free of marine borer attack after 9 years' exposure.

2.5-17-5/81

U S GOVERNMENT PRINTING OFFICE 1981-750-027/1